State of CERES

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CERES Science Team Meeting, April 26-28, 2016
NASA Langley Research Center, Hampton, VA

CERES Meeting & Workshop Objectives

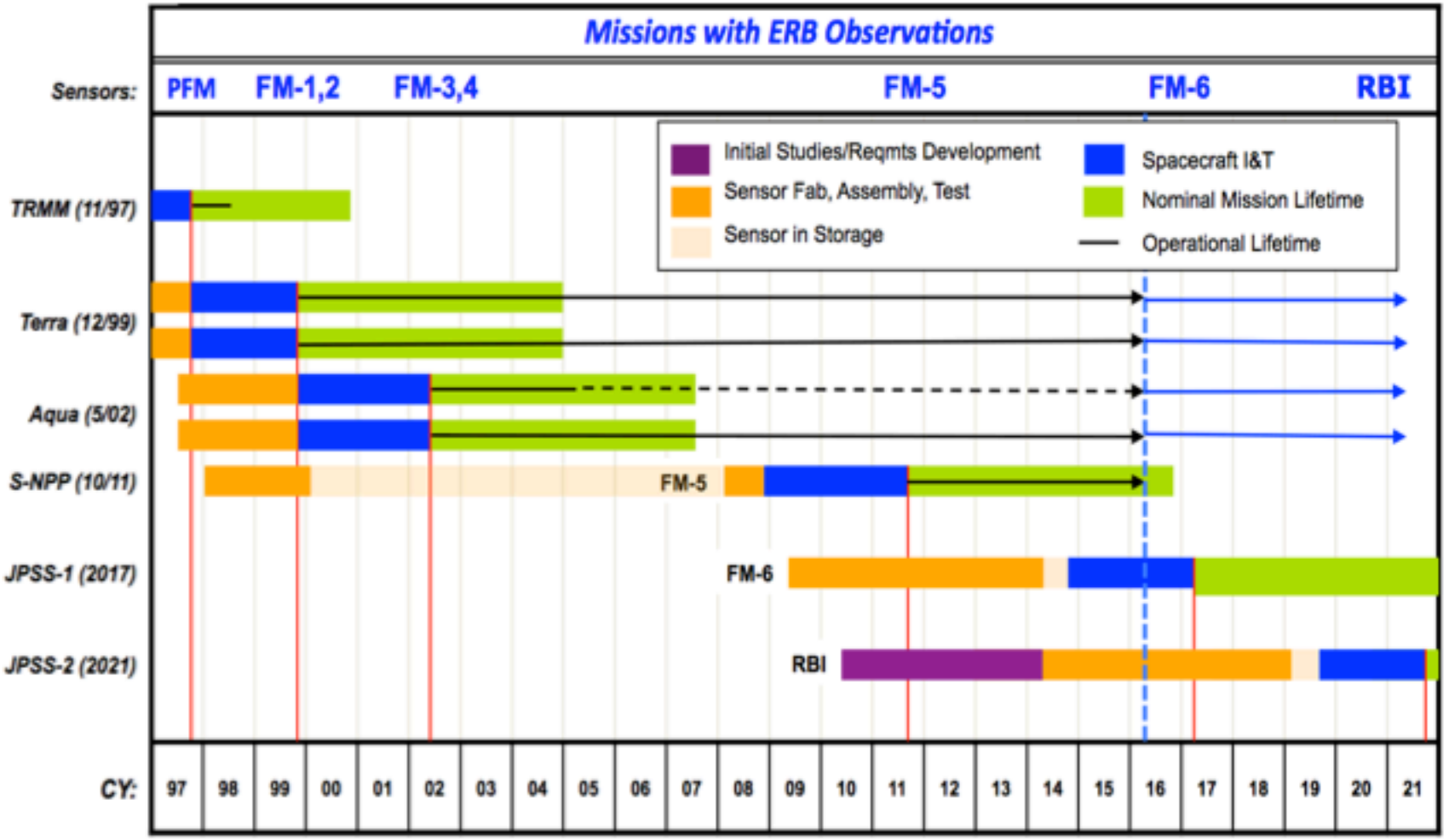
Major Objectives for the Meeting:

1. Review status of CERES Instruments and Data Products:
- Status of CERES
- CERES Terra, Aqua, S-NPP SW/LW/TOTAL Channel Calibration Update
- CERES FM6 and RBI Update
- MODIS & VIIRS Cloud Algorithm & Validation Status
- ADM, SOFA, SARB and TISA Working Group Reports
- EBAF-TOA & EBAF-SFC Edition 4 Updates
- FLASHFLUX Update
- Data Management Team Update: Terra/Aqua/S-NPP
- Atmospheric Sciences Data Center (ASDC) Update
- CERES Communication Activities

2. Invited Presentations Session: Each presentation is 45 min.

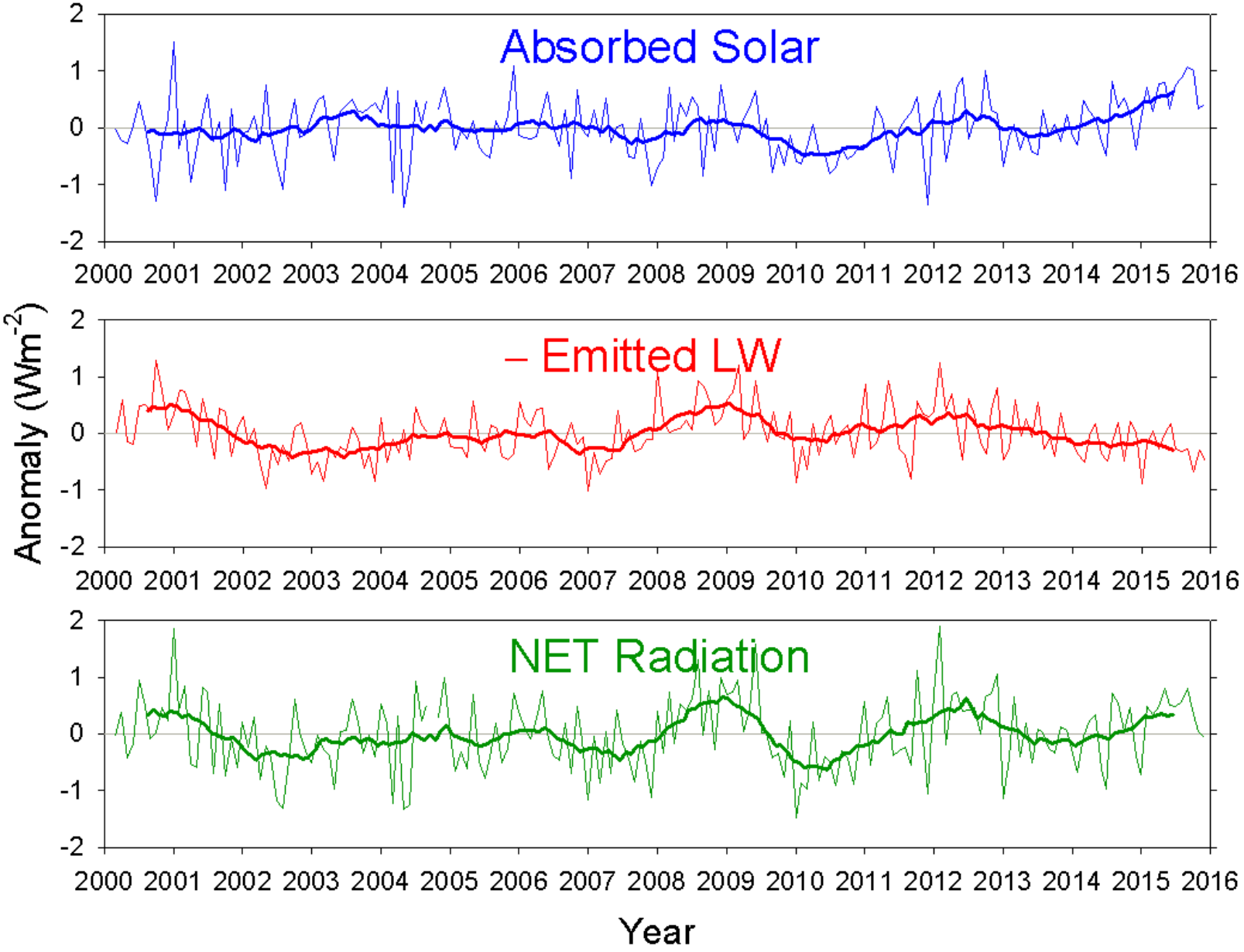
3. Contributed Science Reports. Each report is 20 min including time for questions.

CERES & RBI Flight Schedules

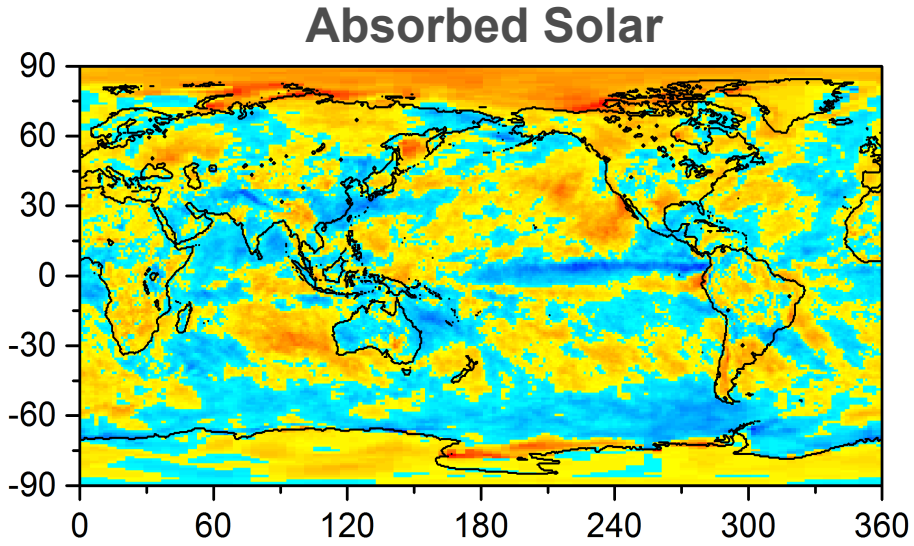


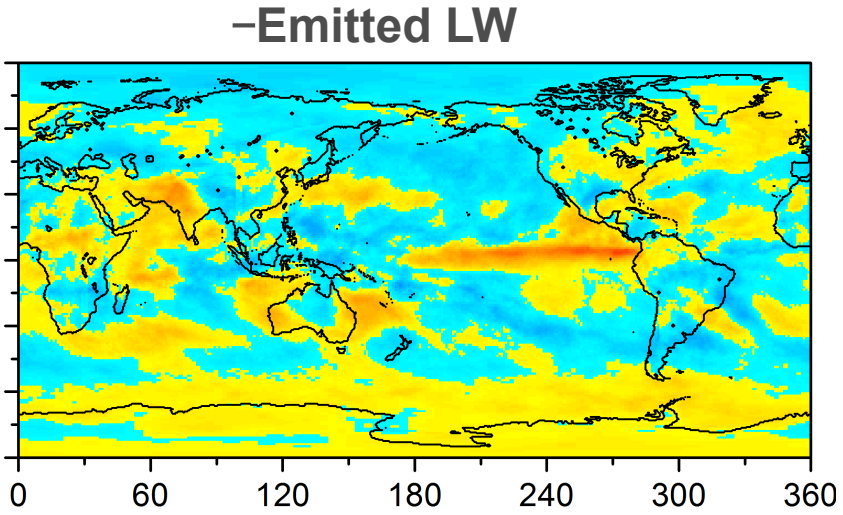
- Currently, 5 CERES instruments fly on 3 satellites: Terra (L1999), Aqua (L2002) and SNPP(L2011).
- CERES FM6 will fly on JPSS-1 in FY17 (2nd Qtr). The CERES follow-on instrument (Radiation Budget Instrument, or RBI) will fly on JPSS-2 in FY21 (4th Qtr).

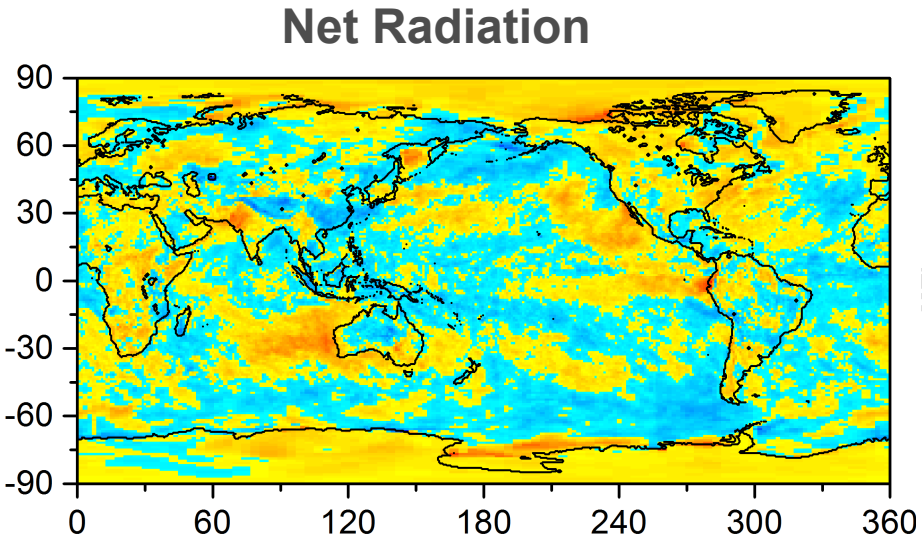
Global TOA All-Sky Radiation Anomalies
(CERES_EBAF_Ed2.8; 03/2000 – 12/2015)

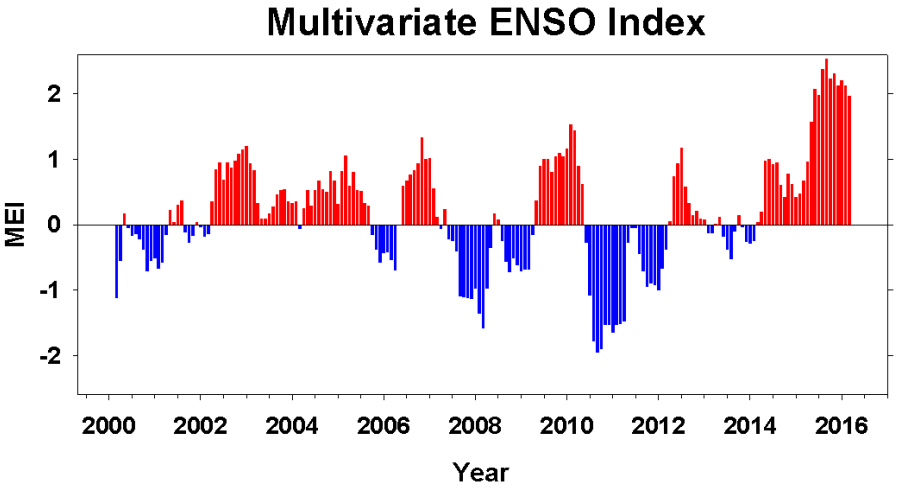


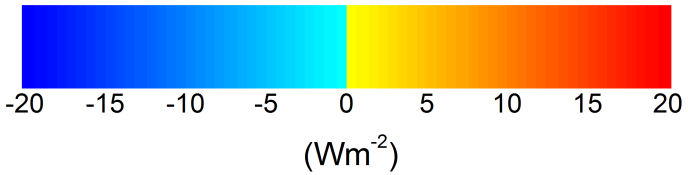
TOA Radiation Changes (March 2000 – December 2015)





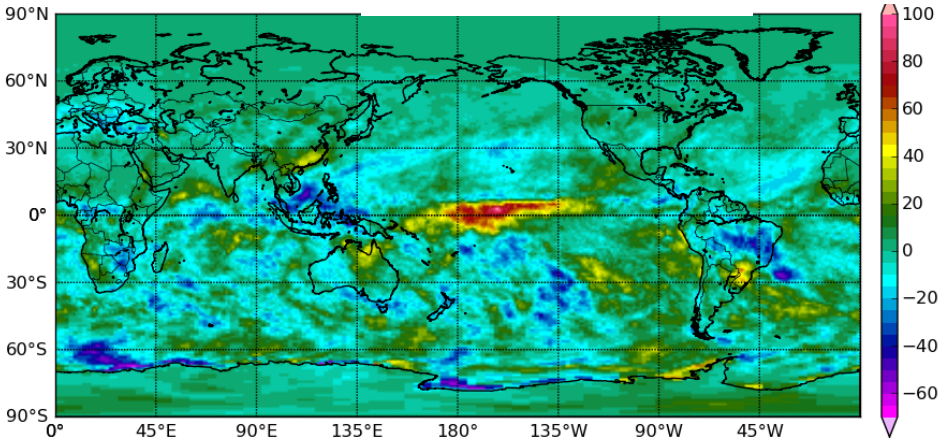




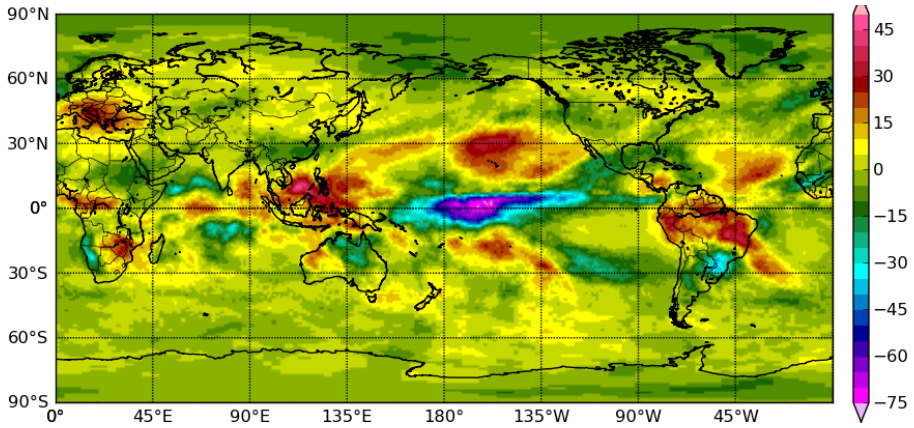


TOA Flux Anomalies for December 2015 (Strong El Niño Event)

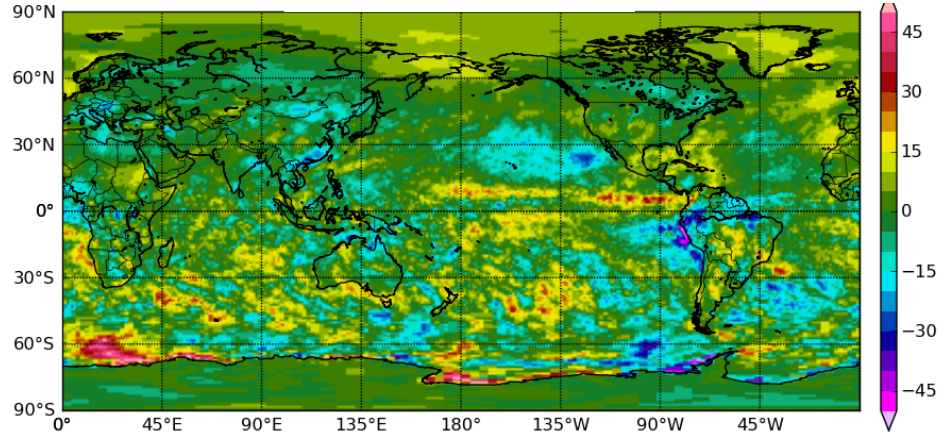
Reflected Solar



Outgoing LW



Net Radiation



CERES Reviews During Coming Year

1) Earth Radiation Budget Science PPBE Review (May 5, 2016)

2) Earth Radiation Budget Science Team Review (May 23, 2016)

3) Terra, Aqua and S-NPP Senior Reviews
   - Proposals to be submitted in early March 2017

CERES Terra Anomaly

- Between February 18-24, 2016 Terra spacecraft and all instruments were in Safe Mode.

Cause:

- During a scheduled inclination maneuver, the instrument was yawed to +90° instead of the required -90° YAW.
- When attempts were made to slew it back, the edit limits were tripped and caused the spacecraft to go into Safe Mode.
- Spacecraft and all instruments were powered back on without issue after February 24.
- Spacecraft and all instruments continue to operate nominally.
- Independent Review Board set up to investigate MO processes.

Proposed Waiver to Terra Constellation Exit Plan

- **Original plan**: In order for Terra to exit the morning constellation safely, it must first lower its orbit to 19 km below the constellation.
  - An orbit-lowering maneuver would be performed in 2017 and the spacecraft would then naturally slowly drift down to 10:15 am MLT by 2022.
  - Terra satellite reentry would occur in 2057.
- Upon further analysis, it was determined that this safe exit approach was overly conservative: safe exit only needs to be approximately 4 km below the constellation.

Proposed Waiver to Terra Constellation Exit Plan

- **Proposed Plan**: Terra would like to pursue exiting the constellation according to the new constellation exit requirement of 4 km instead of 19 km.

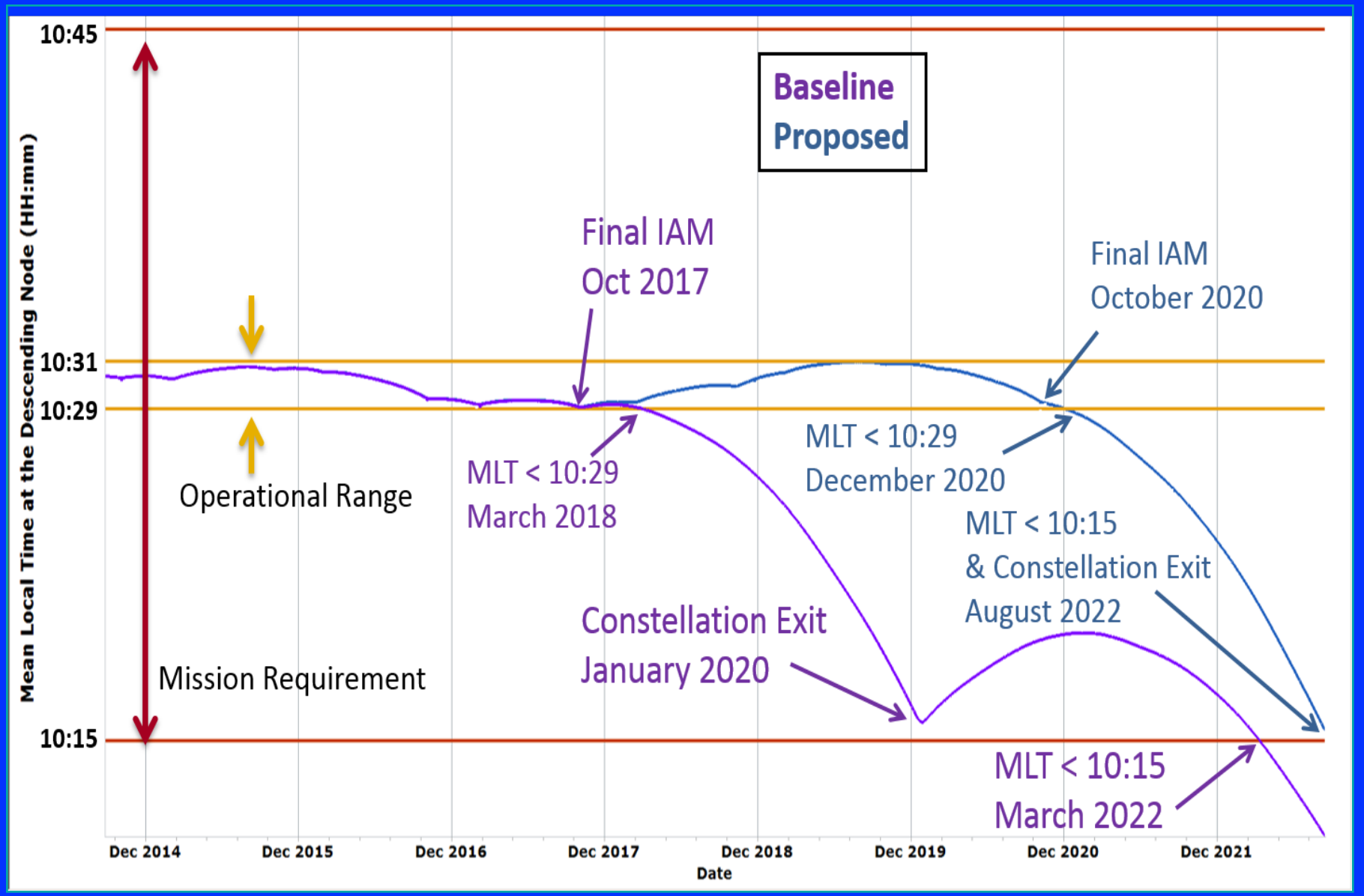
  ⟹ Would require fewer maneuvers to exit the constellation and therefore less propellant would be needed in reserve for constellation exit.

  ⟹ Would enable Terra to maintain the 705 km altitude and the tight 10:30 MLT for nearly three additional years (it's been within 1 min since early in the mission).

  ⟹ Terra satellite reentry would occur in 2077.

NOTE: In either scenario, Terra will be able to collect science data through 2025 when the MLT drifts past 9:00 am.

Terra MLT following baseline constellation exit vs proposed exit



Issues/Concerns with Proposed Waiver

Additional Debris Risk: If lowered 4 km below the constellation, Terra satellite would remain in orbit for 20 more years (2077 vs 2057) before reentry.

⟹ Increases chance that Terra could be hit by a piece of debris before reentry and thus create more debris in low Earth orbit altitude regimes.

- However, the increase in collision risk to a typical member of the 705 km Earth Science Constellation is minimal.
- To get an independent assessment, ESMO asked the Aerospace Corporation to perform a constellation risk analysis between the two exit strategies:

Orbit	Risk of Terra Breakup
4 km (701 km)	1 in 100,000
19 km (686 km)	1 in 103,100
Current (705 km)	1 in 108,700

2015 Senior Review Panel Recommendation

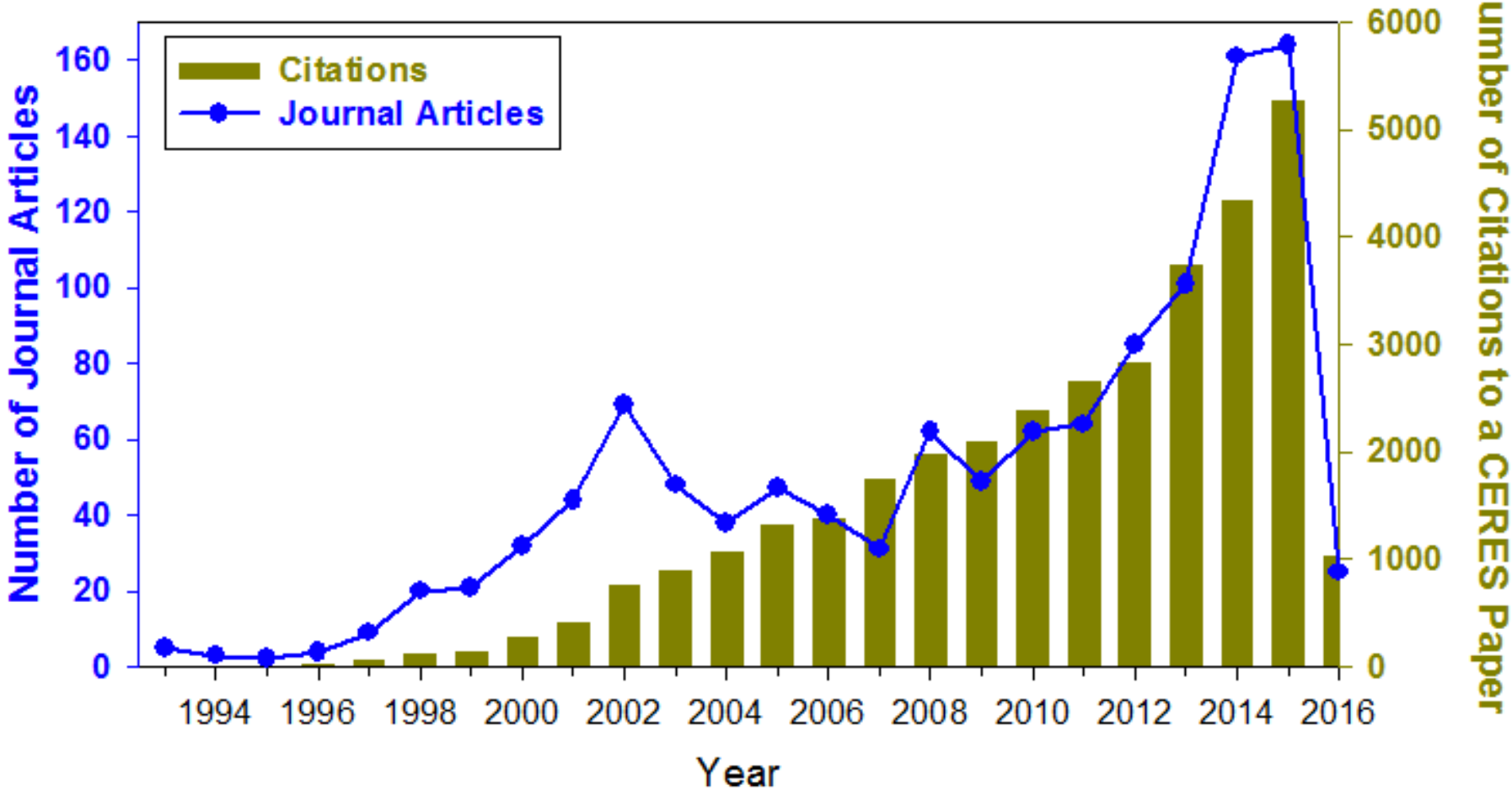
- If the waiver is denied, Terra would certainly continue to collect high quality data of sufficient value to the science community to warrant extension.
- Orbital change would compromise continuity of the stable long term climate record at some level, but additional information is necessary to fully assess the significance of this degradation.
- A sensor-specific or even data product-specific table of risks to data continuity resulting from waiver non-approval is needed.
- Panel suggests that NASA convene a workshop of data users to discuss and evaluate the trade-offs associated with the waiver decision.

Current Status

- Terra Workshop held March 29-31 to discuss MLT issue.
- Impact is greatest for MISR team due to how they process data. For CERES, there is no impact on processing.
- New review panel was sent a White Paper outlining the impacts and scientific benefits of maintaining a 10:30 am MLT for 3 additional years.

  => Panel recommendation was to hold MLT at 10:30 am for as long as possible.
- Terra mission operations presented case for holding MLT to Mission Operations Working Group (MOWG).
- Decision now up to NASA HQ.

CERES Journal Publication and Citation Counts
(For Papers Between 1993-2016; Updated April 18, 2016)



- Total number of peer-reviewed journal articles: 1,186
- Total number of citations to CERES papers : 34,467

Compiled by Anne Wilber & Dave Kratz

Number of Unique Users by CERES Data Product (Updated April 14, 2016)

Level	Product	2010	2011	2012	2013	2014	2015	2016
1b	BDS	11	9	14	19	14	11	6
2	SSF	84	77	138	223	247	253	101
	FLASH_SSF	25	8	15	23	30	61	8
	C3M	31	32	33	37	28	55	15
	ES8	22	20	18	31	16	21	3
	SSF-MISR	9	4	2	5	4	2	0
3 & 3b	EBAF-TOA	72	160	346	484	579	580	162
	EBAF-Surface			147	289	375	424	155
	SYN1deg	70	139	188	331	375	431	169
	SSF1deg	77	126	107	157	166	160	71
	ISCCP-D2like	17	12	37	57	41	40	16
	ES4	59	36	11	27	19	13	5
	ES9	21	12	5	13	9	5	1
	FLASH_TISA	17	18	20	17	15	15	1

CERES Terra and Aqua Edition 4 – Status

- Instrument gains and SRFs: Delivered
  - Improvement to Aqua SW part of TOT SRF.
- CERES Clouds code: Delivered.
  - Increased cloud fraction (more consistent with CALIPSO).
  - Decreased cloud optical depth (more thin clouds).
  - Significant improvements to polar cloud mask.
- Inversion (ADMs and SOFA) code: Delivered.
  - 2nd generation CERES ADMs; Improved parameterized surface fluxes.
- SARB and TISA code: Delivered.
  - Use of 5-channel 1-hourly GEO cloud retrievals.
  - Consistent reanalysis and MODIS calibration throughout.
  - SYN1deg to be released 1-hourly, 3-hourly, daily and monthly.
  - Consistent non-GEO and GEO TISA products (all GMT).
  - Improved to Fu-Liou RT code and ancillary inputs (e.g., Ed4 clouds+overlap, surface albedo, MATCH aerosols).

CERES Terra and Aqua Edition 4 Status

Current Processing:

- BDS processed through December 2015
- SSF processed through December 31, 2014
- SSF1deg processed through November 2014
- SYN1deg processed January 2005 – December 2011

Anticipated Level 3 Release Dates

- SYN1deg anticipated release – June 8th, 2016
- CldTypHist anticipated release – August 10th, 2016

EBAF Ed4.0

(After 5 years have been processed):

- Summer 2016

CERES FM5 SNPP

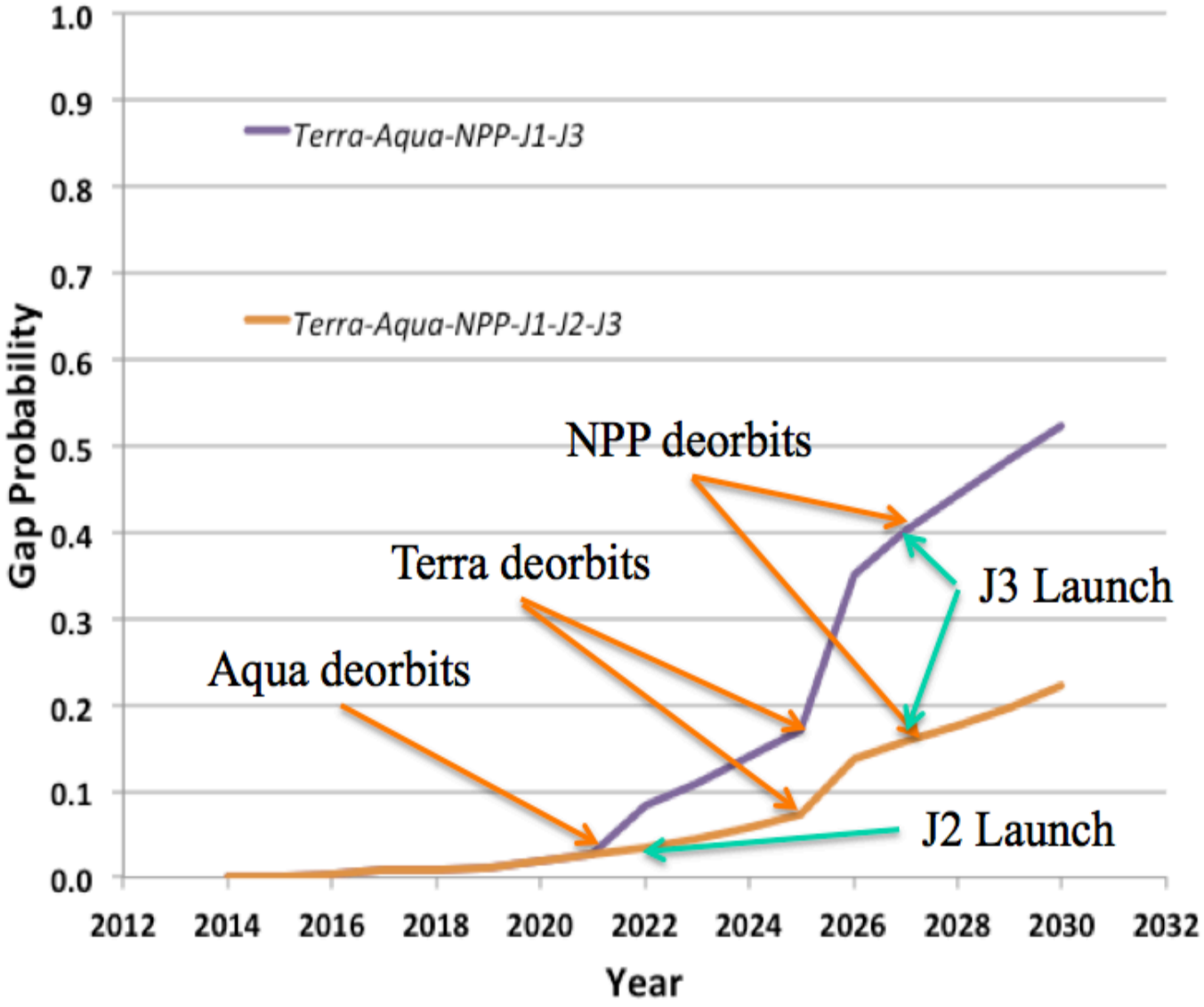
- CERES FM5 time-varying gains and beginning of mission SRFs used in SSF Edition 1.
- Receiving Collection 1.1 calibrated VIIRS radiances from GSFC Land PEATE (Xiong).
- CERES Edition 1 Clouds: Delivered.
- SSF Edition1 uses Edition 4 Aqua ADMs.
- Anticipate “MODIS-Like” VIIRS aerosols from Land SIPS (POCs: Rob Levy & Christina Hsu). Consider including in Edition 2.
- Current Status: Ed1 SSF processed through December 2015.
- SNPP Ed1 Level-3 code deliveries needed in coming months (SSF1deg; SYN1deg).

Future Earth Radiation Budget Missions

- CERES FM6 to launch on JPSS-1 in early 2017.
  - CERES team to produce Earth Radiation Budget Climate Data Records using CERES FM6, closely following FM5/SNPP approach.
- Radiation Budget Instrument (RBI) Status:
  - Draft RFP released in April, 2013
  - Industry-Day April 30, 2013
  - Official RFP release: June 14, 2013
  - Award: Spring 2014
  - RBI delivery date: Spring 2019.
  - Launch on JPSS-2: November 2021.

Radiation Budget Gap Probability

Missions terminate: primary operational sensor or spacecraft fails, or fuel too low



Assumptions:

- Constant Failure Rates (electronics dominated)

- Decommission satellites after primary operational instrument fails (e.g., MODIS for Terra & Aqua, VIIRS for NPP, CrIS for JPSS 1, 2, 3) or low fuel

- Battery, gimbals, etc. are not life limiting issues

- If fuel is too low (de-orbit for safety reasons) mission is then terminated.

JPSS-1 launch mid-2017
JPSS-2 launch late 2021
JPSS-3 launch late 2026

De-Orbit for Fuel Limit:
Terra 2025
Aqua 2021
NPP 2027

COVE

- DOE has turned Ches Light over to GSA for excess; GSA expects to put Ches Light up for auction this week.
- Owner of Frying Pan Shoals likely will not make an offer.
- DOE is not allowing trips to Ches Light, citing safety concerns.
- BSRN instrument suite is operating autonomously at COVE. AERONET instrument is broken.
- A 2nd BSRN instrument suite is operating at CAPABLE.
- Approval to operate MPLNET at CAPABLE was finally granted.

Upcoming Conferences & Meetings of Interest

CFMIP/WCRP/ICTP Conference on Cloud Processes, Circulation and Climate Sensitivity
- July 4-7, 2016, Trieste, Italy

Asia Oceania Geosciences Society (AOGS) 13th Annual Meeting
- July 31-August 5, 2016, Beijing, China

AMS Satellite Meteorology
- August 15-19, 2016, Madison, WI

Fall 2016 CERES Science Team Meeting (Joint with ScaRaB & GERB)
- October 18-21, ECMWF, Reading, UK.
- www.ecmwf.int/en/learning/workshops-and-seminars/earth-radiation-budget-workshop
- Registration is required.

American Geophysical Union
- December 12-16, 2016, San Francisco, CA

AMS Annual Meeting
- Jan 22–26, 2017, Seattle, WA

3rd International A-Train Symposium 2017
- April 19-21, 2017, Pasadena, CA

Other CERES Related News

- Terra lunar deep space calibration maneuver.
  - Targeting July 2017
  - Will likely need NASA HQ approval
- CERES/ScaRaB PAPS campaign (March 22 – May 31).
  - Idea is to repeat campaign conducted two years earlier to assess any instrument changes between the two campaigns.

Other News

- SORCE operating in “hybrid” mode (collecting solar measurements during orbit day and then going into safe-hold during eclipse periods to conserve battery power).
- TSIS-1 is planned for a launch on ISS in August 2017.
- CALIPSO – Functioning nominally
- CloudSat – Returned to the A-Train. Nominal Daylight Only Operations (DO-Op) continue.
- Deep Space Climate Observatory (DSCOVR)
  - Launched Feb 11, 2015.
  - Reached its orbit position between Earth and sun at Lagrange point 1.5 million km from Earth on June 8.
  - First image of entire sunlit side of Earth on July 20.
  - EPIC and NISTAR are the Earth-viewing instruments.
  - LaRC received grant to generate NISTAR fluxes (Minnis/Su Co-Pis).

Other News

- Cloud-Aerosol Transport System (CATS) on ISS
  - Launched Jan 10 and installed on the ISS Jan 22. First science data received in February.
  - Backscatter & depol. lidar at 355, 532 and 1064 nm; HSRL at 532 nm.
  - 51 deg inclined orbit of ISS => diurnal sampling of clouds & aerosols.
  - LaRC CALIPSO team to develop CALIPSO-Like data product.
  - CATS 1064 nm backscatter continues to operate nominally (no HRSL).

- CLARREO Pathfinder mission on ISS in FY2019 in President's budget.

End